Forest Health Protection

Pacific Southwest Region

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To: District Ranger, Hat Creek RD, Lassen National Forest

Subject: Biological Evaluation of insect and disease problems in Hat Creek and Bridge Campgrounds, Hat Creek RD, Lassen National Forest (FHP Report NE11-05).

This serves as a letter of recommendation for the removal of hazardous pine trees with suspected root decay in Hat Creek Campground and hazardous snags in Bridge Campground which died following a recent wildfire.

Bill Woodruff, Forest Health Protection (FHP) Plant Pathologist and Amanda Garcia-Grady, FHP Entomologist met with Hat Creek RD Staff: Ben DeBlois, Project Forester, Naomi Brown, Small Sales Prep Specialist, Johanna D'Arcy, Small Sales Forester, and Tami Taylor, Recreation Officer on February 1, 2011 to assess insect and disease conditions impacting stands at Hat Creek and Bridge Campgrounds. Of particular concern was the recent blow down of a large diameter ponderosa pine and the implication of *Heterobasidion irregulare* (formerly referred to as *H. annosus* or P-type annosus root disease) at Hat Creek Campground. Bridge Campground is currently experiencing high levels of insect-caused tree mortality in fire-injured trees.

In Hat Creek Campground a 120 ft, 33" DBH ponderosa pine with a healthy green crown blew down this past winter while the campground was closed to public access. The roots of the fallen tree exhibited resin soaking and stringy decay (white rot) which is consistent with symptoms often associated with *Heterobasidion irregulare* infection (Figure 1). Since fruiting bodies of *H. irregulare* were not found, positive identification of the fungus was not possible. Decayed root samples were sent to U.C. Berkeley to identify the fungus through DNA testing (results are pending).

It is important to note that the fallen ponderosa pine was located adjacent to a paved road. Its roots could easily have been injured and infected with decay fungi during construction of the road. Whether or not *H. irregulare* is the fungus responsible for the tree failure, root decay caused by some unknown fungus compromised the stability of this tree. This root decay may also be decaying the roots of five large pine trees growing near the failed tree (Figure 2). The first and most likely to have advanced root decay is a 36" DBH Jeffrey pine (circled crown on the right) with a fading top and declining crown growing five

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feet from the failed tree (Figure 1A [left bole]). We recommend the removal of this Jeffrey pine tree as its root base was probably compromised by the blow down event. When it falls, this tree could strike at least two occupied campsites and will be a threat to life and property.

The condition of the roots of the remaining pine trees in Figure 2 is less certain. Only the circled crown on the left is declining. This could be due to root disease or a number of other biotic or abiotic factors. We are quite sure that these trees are close enough to the fallen ponderosa pine to have contracted the disease through root contact; that they could have advanced root decay; and that any of these trees could strike an occupied campsite, should they fall. The most conservative action would be to cut down all five trees in Figure 2 in order to maintain public safety and error on the side of caution. A less conservative action would be to cut down only the two pine trees circled in red in Figure 2, and monitor the remaining three trees for future changes in crown health which might indicate a possible deterioration of the roots.

Choosing the latter action is not without risk; especially considering the fact that the fallen ponderosa pine tree appears to have had a green crown. Given the healthy appearance of the crown, it would have been difficult to predict this tree failure prior to the event. Two traits all five of the trees in Figure 2 have in common with the fallen tree is the fact that they are all quite old and they all appear to have sparse foliage, relative to much younger pine trees of similar height. An exception might be the pine on the extreme left in Figure 2, which appears to have a healthier crown. A decision to leave this pine would have some merit, as would a decision to remove all five in the interest of safety.

This occurrence emphasizes the importance of being ever vigilant in carefully examining all large trees in recreation areas and administrative sites for subtle or obvious changes that might indicate a potential tree failure. Questionable trees should be identified and monitored. Trees, like other living things, decay more rapidly as they become very old. This decay is often hidden, especially when it exists in the roots. Managers need to key in on a subtle deterioration in the condition of the crown of a tree in order to anticipate root decay which might make that tree hazardous. When a tree failure occurs, we need to learn from the circumstances of that failure and be especially cautious of similar-appearing trees.

As a reminder, the best management for root and stem decay is prevention. When building roads and trails, burying utilities, constructing campsites, etc. the roots and boles of trees need to be protected. Once the bark is damaged and the wood is exposed, decay fungi can enter. Once decay fungi enter a tree and begin growing, there is no economically feasible cure, except to remove the tree or accept its consequences. By protecting desirable leave trees from mechanical damage, root and stem decay can be minimized. During thinning treatments, roots can be protected from heterobasidion root disease by treating the freshly-cut stump with borates. Sporax® and Cellu-Treat® are the borates registered in California for this purpose. Region 5 requires treatment of all freshly-cut conifer stumps in recreation areas and other high value sites.

Other forest health issues: Certain areas of Hat Creek Campground have a dense understory of conifers which are competing with overstory trees for limited site resources (Figure 3). Under drought conditions overstocked pines (> 6" DBH) may become susceptible to bark beetle-caused tree mortality.

In Bridge Campground, high tree density, recent fire-injury (2008 Sugar Loaf Fire) and drought have facilitated bark beetle-caused tree mortality in ponderosa pine, white fir and incense cedar (Figures 4 and 5). A dense patch of approximately 30 ponderosa pine trees initially injured by fire were subsequently attacked and killed by the western pine beetle, *Dendroctonus brevicomis*. A large number of small diameter incense cedars in Bridge Campground received significant fire-injury to lower boles and roots. This is because the bark of young incense cedar is thin and offers little protection from heat-induced cambium injury (Tollefson, 2008) and branch roots of incense cedars grow to within 1.2 inches of the soil surface (Stein 1978) rendering them susceptible to injury from surface fires. These trees are now being attacked and killed by cedar bark beetles, *Phloeosinus* spp. (Figure 5) which ordinarily would not kill healthy trees. These trees were likely predisposed to *Phloeosinus* beetle attacks by a combination of fire-injury, stress from high tree density and recent drought conditions.

Timely thinning of the overstocked stands within both campgrounds is recommended to improve tree vigor and reduce their susceptibility to bark beetle attack. This is particularly important given the regular occurrence of drought in California (Ferrell, 1996) and the forecast of increasing drought frequency with climate change (Seager et al 2007). The standing dead beetle-killed trees in Bridge Campground pose a safety threat to the public and should be felled before the campground is opened to the public.

If you have any questions and/or need additional information please contact Amanda Grady at 530-252-6675 or Bill Woodruff at 530-252-6680

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Figure 1. A) Suspected *H. irregulare* infected 33" DBH ponderosa pine blow down; and 2) decayed roots

Figure 2. Large pines near fallen 33" DBH ponderosa pine. Circled crowns have fading tops and dead branches.

Figure 3. High competition from the understory cohort of pines in some locations of Hat Creek Campground is rendering larger diameter trees susceptible to drought and bark beetle-caused mortality.

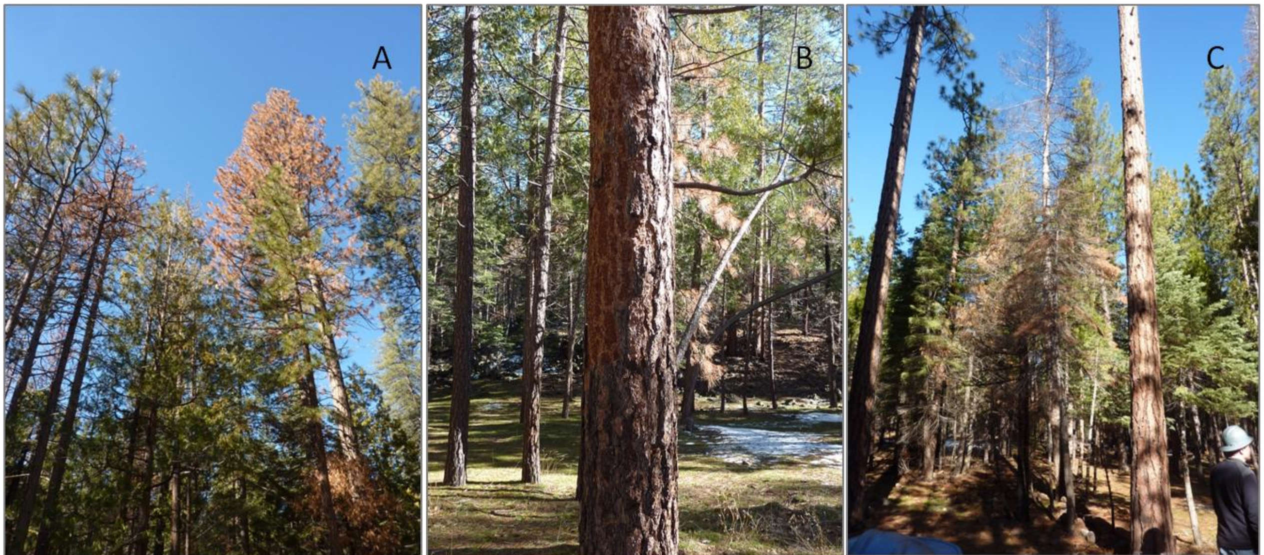

Figure 4. Tree mortality in Bridge Campground caused by fire injury and bark beetles: A) ponderosa pine; B) bark flaking by woodpeckers indicates western pine beetle activity; C) white fir.

Figure 5. Incense cedar mortality caused by A) fire-injury and *Phloeosinus* beetles and B) beetle exit holes on incense cedar bole.

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Insect and Disease Information

Western Pine Beetle (*Dendroctonus brevicomis*)

Hosts: Ponderosa pine and Coulter pine

Distribution in California: Throughout the range of suitable host trees.

Identification: Smallest of the western *Dendroctonus* species, this black cylindrical beetle is about the size of a grain of rice (4 mm long). Egg galleries are winding and packed with frass. Larval galleries lead away from the main gallery for short distances before turning into the outerbark. Small, reddish pitch tubes (sometimes fairly obscure) are signs of successful attack. Attacked trees often exhibit woodpecker feeding with only portions of the outer bark removed. Sapwood of infested trees usually shows evidence of the characteristic bluestain associated with fungi introduced by attacking beetles.

Effects: Successful attacks result in death of the host tree. Groups of trees are sometimes killed, especially when growing under crowded conditions. Since larger trees are generally preferred, the western pine beetle can dramatically alter the character of a forest that comes under attack.

Ecological Role: The western pine beetle serves as a key mortality agent for ponderosa pines weakened by the effects of old age, drought, smog, diseases, or competition with other trees. Stand structure can be altered and gaps can be created in the stand as the bark beetles kill larger trees, either singly or in groups. In those instances where ponderosa pine occurs in mixed stands with firs, the western pine beetle can accelerate the successional process by selectively removing the early seral species from the stand. Trees infested by the western pine beetle provide temporary food sources for woodpeckers and other insectivores. Infestation by western pine beetle sets the stage for other agents, such as wood borers and decay fungi that are involved in the recycling of nutrients back into the soil.

Life History: In the northern part of its range and at higher elevations, the western pine beetle completes two generations in one year, with adult beetles flying in early to mid June and mid to late August. In the southern part of its range and at lower elevations, the beetles produce three and sometimes four generations per year. Attacks may be as early as March and as late as November. Female beetles locate a suitable host and initiate attacks by burrowing through the bark. They release a pheromone that attracts other beetles and leads to mass attacks of the host tree and sometimes several trees in a group. Each female lays about 60 eggs in individual niches cut in the sides of the egg gallery. These eggs hatch in two weeks and young larvae feed initially in the phloem, later moving into the outer bark where most of their development takes place. After four larval stages, the insects turn into pupae and then adults.

Conducive Habitats: The western pine beetle breeds most commonly in trees of reduced vigor. While older, larger trees are generally preferred, younger trees can also be infested, especially when they occur in dense stands, are infected by pathogens, or are damaged by fire. During periods of drought, the western pine beetle will be particularly prominent and can overcome apparently healthy trees.

Similar Insects: Other bark beetles attacking ponderosa pine may be distinguished from western pine beetle by their egg gallery characteristics and adult appearance. Egg galleries of the mountain pine beetle are straight and vertical, and those of the engraver beetles possess a nuptial chamber with one to several tunnels radiating out from it. Engraver beetle egg galleries are free of frass. Ips adults display a pronounced concavity at the rear end of the elytra that possesses three to six spines on either side. The elytral declivity on *Dendroctonus* adults is rounded and does not possess any spines.

Management Strategies: The detrimental effects of western pine beetle can best be minimized by providing vigorous growing conditions for host trees. Stand densities below the "Upper Management Zone" (Cochran 1992; Cochran et al 1994) will provide sufficient growing space for trees and will minimize potential habitat for the western pine beetle. *Dendroctonus* beetle group-kills cause a limiting Stand Density Index of 365 that differs little between stands on good and poor sites in California (Oliver 1995). In the past, "high-risk" trees (those most likely to be infested by the western pine beetle) were identified by various hazard rating systems (Keen 1936; Salman and Bongberg 1942; Smith et al. 1981) and removed. Short-term treatments are also available to protect individual, high value trees such as spraying insecticides on tree boles to prevent bark beetle attacks. Other short-term treatment options for individual trees are currently being evaluated such as the use of anti-aggregation pheromones and non-host angiosperm volatiles. Tree injection systems are being explored to treat trees with systemic insecticides.

Cedar Bark Beetles (*Phloeosinus* spp.)

Hosts: Coast redwood, giant sequoia, incense-cedar, Monterey cypress, Port Orford-cedar, and western juniper.

Distribution in California: Throughout the range of suitable host trees.

Identification: External evidence consists of twig killing (or flagging) or whole tree fading. This is usually accompanied by the presence of reddish brown boring dust in bark crevices. Egg galleries are simple and typically longitudinal, 2 to 7 cm long, and are often deeply etched into the wood. Egg niches are usually rather large and conspicuous. Larval galleries wander away from the parent galleries. Adults are reddish brown to black, shiny beetles ranging in size from 2 to 4 mm long.

Effects: Main effects on their hosts are twig killing or tree mortality; however, these insects are not aggressive and are generally found only attacking trunks, tops and limbs of weakened, dying or felled trees. They readily colonize broken branches and logging slash. As secondary insects this group does not often outbreak.

Life Stages and Development: One to three generations are produced per year. Attacks occur in spring and summer. Newly emerged adults feed on the pith of twigs of living trees prior to constructing egg galleries under the bark. These twigs are often hollowed out completely causing them to die and partially break off and hang from the tree.

Similar Insects: This is the main bark beetle genus attacking redwood, cedar, cypress and juniper. There are some woodboring beetles that also attack these trees but are not similar in appearance or feeding habits.

Fir Engraver (*Scolytus ventralis*)

Hosts: True firs

Distribution in California: Throughout the range of true fir.

Identification: The fir engraver is a medium-sized bark beetle, measuring about 4 mm in length. It is the largest of the shiny black *Scolytus* beetles and is recognized by the concave abdomen typical of the genus. Trees under attack are not always easily recognized, although sometimes boring dust will be evident on the bark. Often, successfully infested trees cannot be differentiated from uninfested trees until the year after attack when their foliage begins to fade. Extensive pitch streaming from entrance holes, and sunken patches of bark, indicate unsuccessful attacks. The adult or egg gallery of the fir engraver is oriented perpendicular to the grain of the wood and larval galleries are parallel to the grain on both sides of the egg gallery. Both the egg and larval galleries deeply score the sapwood.

Effects: All sizes of trees can be attacked and killed by the fir engraver. As opportunists, these beetles often kill trees affected by root diseases or stressed by other insects such as the Douglas fir tussock moth. Sublethal attacks resulting in topkill and branch flagging are also common.

Ecological Role: The fir engraver is a key mortality agent for firs under stress. By killing trees, the fir engraver increases diversity in a stand and creates habitats for numerous organisms that depend on dead wood. Engravers also colonize down material and hasten its recycling by introducing wood decay fungi through the bark.

Life History: The fir engraver completes one generation per year in most locations. Two generations may be possible at lower latitudes and elevations. Adult beetles fly and initiate new attacks between June and September, with peak flight activity in July and August. Females initiate attacks and after mating, construct an egg gallery perpendicular to the grain of the tree. Eggs are laid on both sides of this gallery, and larvae hatchwithin two weeks. Winter is passed in the late larval or pupal stage, and young adults mature by the following summer.

Conducive Habitats: Fir engraver activity is most commonly associated with trees infected by root pathogens. Other stress agents such as defoliating insects can predispose trees to engraver attacks. Typically, fir engraver populations will peak one or two years after a defoliator outbreak subsides. Drought conditions are perhaps the most significant trigger for creating substantial amounts of fir engraver habitat. By far the most impressive fir engraver outbreaks have occurred on dry fir sites (characterized by less than 30" of annual precipitation) during periods of drought. The fir engraver is also associated with windthrows and logging slash, but unlike the pine engraver, does not commonly build populations that can subsequently invade standing trees.

Similar Insects: Other engraver beetles attack red and white fir, including the silver fir beetle, *Pseudohylesinus sericeus*, and other species of *Scolytus*. They may be separated by gallery patterns, depth of sapwood scoring and characteristics of adult beetles.

Management Strategies: Since the majority of endemic fir engraver populations are associated with root diseases, management of these disease pockets will also serve to manage the fir engraver. Stand thinning measures for fir stands on drier sites generally do not seem to yield the same benefits that are seen with pines. However, thinning does typically result in increased growth and vigor and in wetter areas (areas with annual precipitation greater than 30 - 35"). Silvicultural practices aimed at maintaining healthy stand conditions appear to offer the best chance for minimizing engraver-caused mortality. Care should be taken during treatments to minimized tree injury and compaction as residual firs are easily damaged during harvest activities and are sensitive to soil compaction. These additional stresses can make them even more susceptible to fir engraver attacks after treatment than before. Large-scale outbreaks associated with drought conditions can best be managed by reducing the occurrence of the fir host on dry sites. Once an outbreak begins, sanitation/salvage appears to result in little or no population reduction of fir engravers.

Heterobasidion Root Disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentale* (also called the 'S' type) and *H. irregulare* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregulare* (‘P’ type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentale* (‘S’ type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentale* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.